# Remote Process Control using a Mobile Phone

## for '35' series Siemens mobiles

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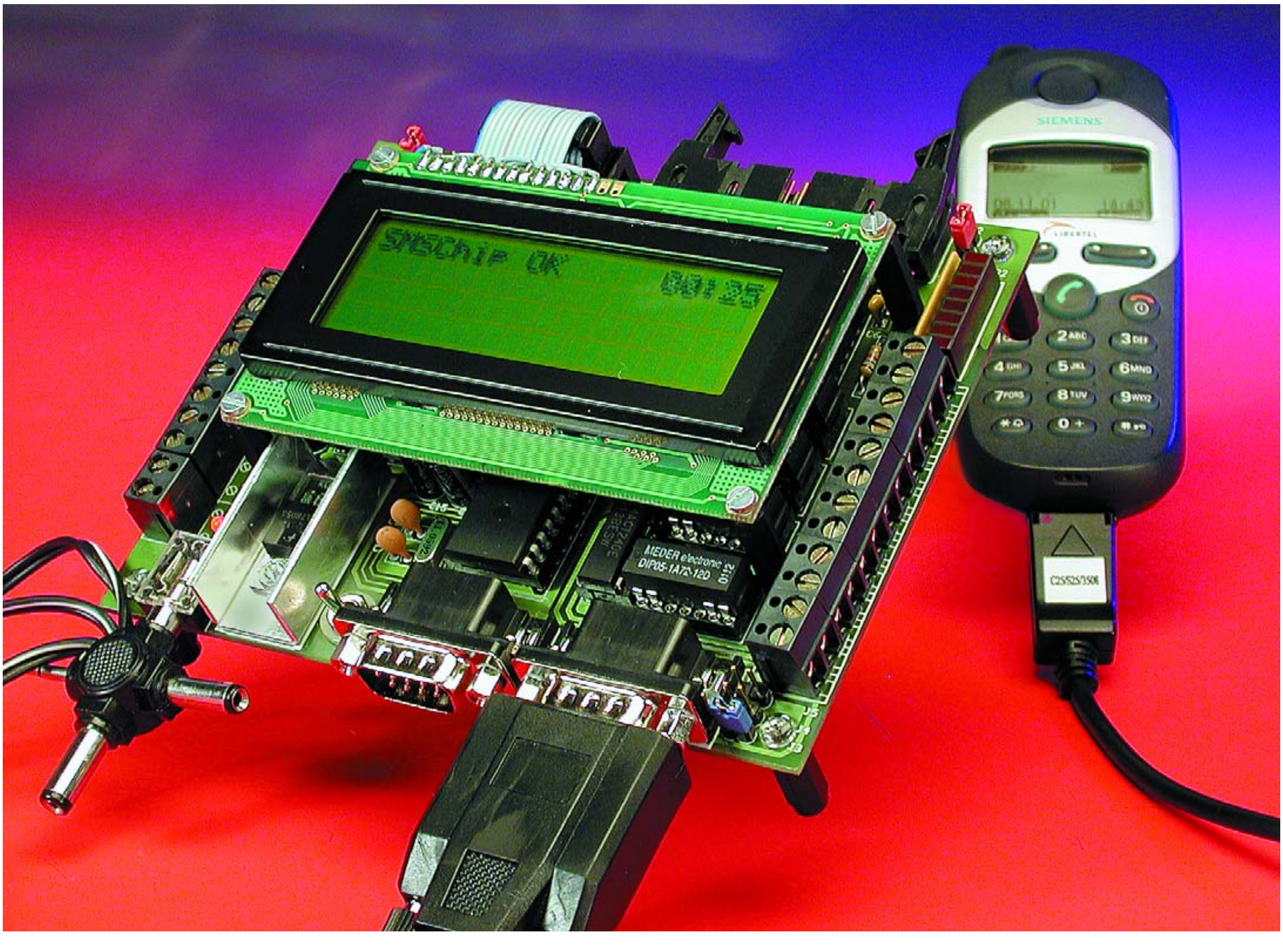
The Short Message System (SMS) of a standard mobile phone can be used for much more than just exchanging cryptic messages. This application finds the humble mobile working in a remote site monitoring and controlling external equipment.



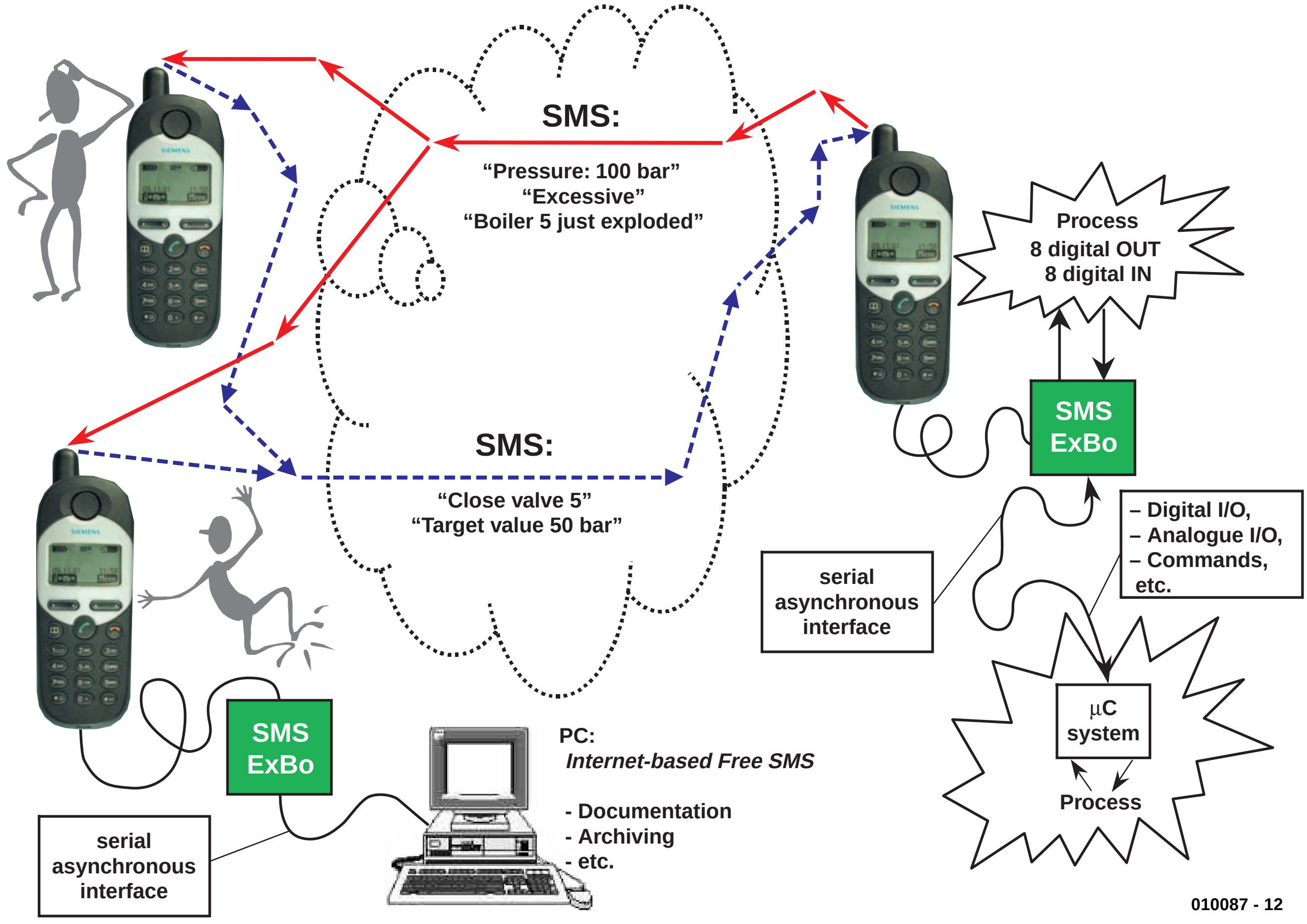


Figure 1. Remote process control using a mobile and SMS.

This design is the result of collaboration between a technical university (TFH Georg Agricola) and the company of Engelmann & Schrader. Together they have produced a flexible, professional remote process controller in the form of an experimentation card (The TFH SMS ExBo). This card connects between the process to be controlled and a mobile phone and allows the process to be controlled and monitored remotely using SMS messages.

## Controlling the process using SMS

The SMS interface board offers two levels of control sophistication. At the basic level it will interpret SMS messages, check the incoming password and directly control output relays or indicators. In the other direction the SMS chip on the interface card inserts information into an SMS message which is then sent over the serial interface connector to the mobile where it will be sent to any SMS-capable phone worldwide. Control information in the SMS message will for example be **`set 10`** this will have the effect of setting output 10 on the interface card and switching on any LED, motor or relay connected to this output. Similarly in the other direction the SMS chip reads inputs to the interface card from the controlled process and generates an appropriate SMS message that will then be passed over the serial interface to the remote mobile where it will be sent out to any SMS-capable mobile worldwide. The message may convey information such as 'Over-pressure detected in tank 3' or 'Intruder alert door 5' or even 'Holiday cottage central heating boiler on' the possibilities are endless.

The TFH SMS ExBo ('Experimental Board') interface board is equipped with a second asynchronous serial interface port and this allows connection of an external computer or process controller at the remote site. This facility gives a higher level of control and monitoring allowing measured values, variables and process status information to be exchanged. With this setup the interface board will initialise the mobile as before but it will pass SMS messages unaltered through to the external computer. This gives the system a much greater flexibility with SMS messages being decoded and generated in the external computer.

## The SMS-Chip

The microcontroller used in this design is the AT89S8252 or AT89LS8252 from Atmel. It is based on the 8051 processor and has an 8 kByte Flash program memory together with a 2 kByte Flash data memory. It is programmed to act as an SMS chip and essentially performs three basic tasks:

- Re-program the mobile and handle communications with the mobile over the serial interface.

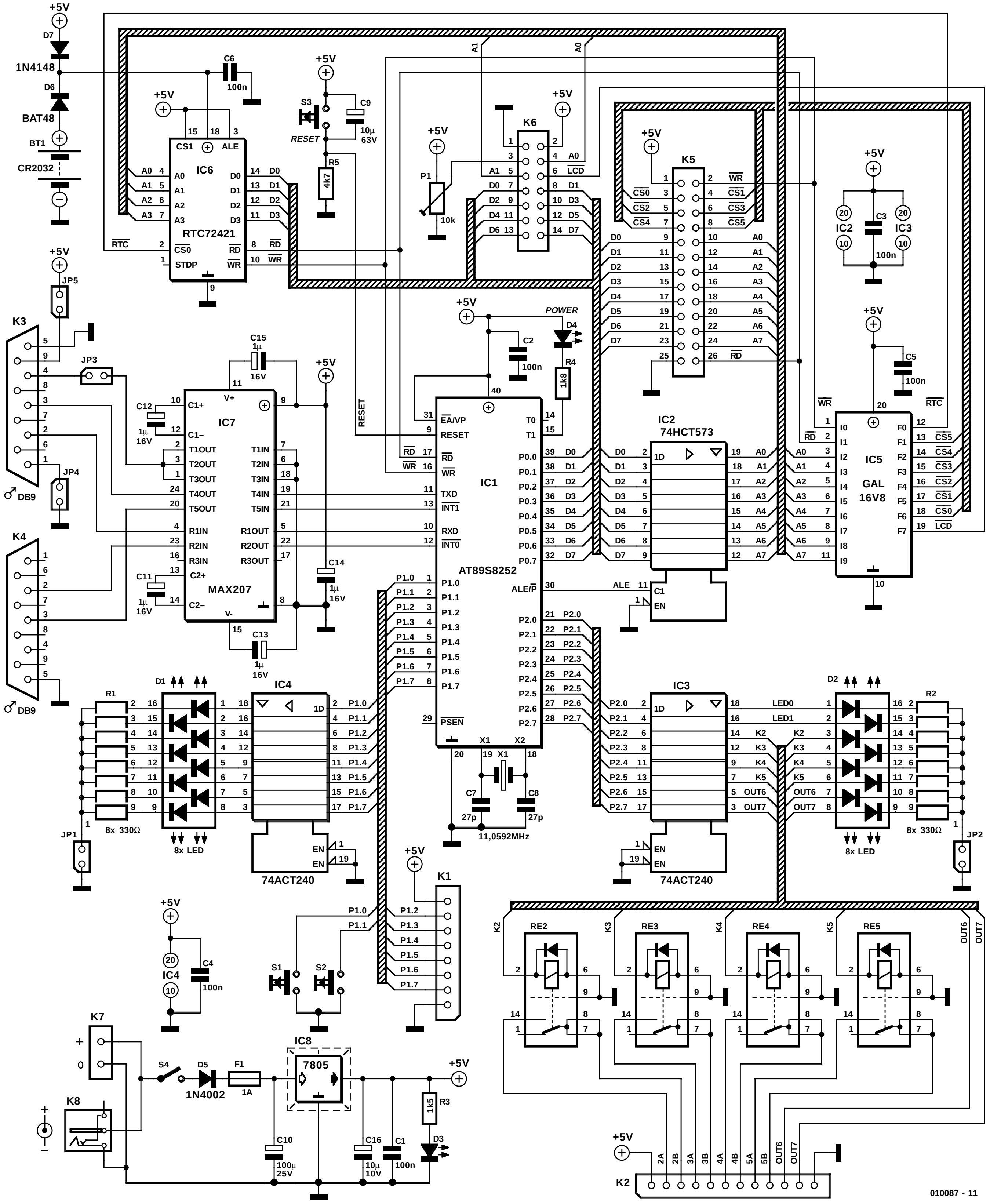


Figure 2. The circuit diagram.

**Table 1. Input/output port specifications**

| Port | Pin No. | Function |
|---|---|---|
| P1.0 | 0 | INPUT : connection for switch S1 |
| P1.1 | 1 | INPUT : connection for switch S2 |
| P1.2 | 2 | INPUT : TTL level, unprotected |
| P1.3 | 3 | INPUT : TTL level, unprotected |
| P1.4 | 4 | INPUT : TTL level, unprotected |
| P1.5 | 5 | INPUT : TTL level, unprotected |
| P1.6 | 6 | INPUT : TTL level, unprotected |
| P1.7 | 7 | INPUT : TTL level, unprotected |
| P2.0 | 8 | OUTPUT: connection LED0 of LED array D2 |
| P2.1 | 9 | OUTPUT: connection LED1 of LED array D2 |
| P2.2 | 10 | OUTPUT: Relay Re2; max. 200 VDC, max. 1 A, max. 15 W |
| P2.3 | 11 | OUTPUT: Relay Re3; max. 200 VDC, max. 1 A, max. 15 W |
| P2.4 | 12 | OUTPUT: Relay Re4; max. 200 VDC, max. 1 A, max. 15 W |
| P2.5 | 13 | OUTPUT: Relay Re5; max. 200 VDC, max. 1 A, max. 15 W |
| P2.6 | 14 | OUTPUT: TTL level from 74AC/HCT240 driver chip |
| P2.7 | 15 | OUTPUT: TTL level from 74AC/HCT240 driver chip |

- Receive and decode SMS messages: monitor and control inputs and outputs of the board. Generate SMS messages.

- Pass messages to and from the mobile and external computer system.

Two 8-bit ports (port 1 and port 2) are available on this chip giving 16 programmable digital input/output lines. The chip also has a built-in Universal Asynchronous Receiver/Transmitter (UART) that handles serial communication and in this application it will pass serial data including SMS messages to and from the mobile. A second serial interface is implemented in software to communicate with the external PC or process controller at 9600 Baud.

The interface board also contains a real-time clock chip with battery back-up and a connector to fit a dot matrix LCD to display SMS messages.

Serial commands are sent to the mobile using standard Hayes modem (AT commands) sequences. For more on Hayes modem control see accompanying text box.

## SMS Chip Hardware

The SMS chip together with some additional peripherals will produce a very basic SMS message handling design but if you look at the circuit diagram in **Figure 2** you will see that the TFH SMS ExBo interface card has been designed to be the basis of a very flexible platform for SMS message development allowing many connection possibilities. The (DIL) SMS chip IC1 is clocked by a standard crystal oscillator configuration (X1, C7 and C8) and a reset circuit is provided by R5, S3 and C9. A low power LED (D4) is driven by output pin P3.5 indicates that the GSM phone is ready. **Table 1** shows the I/O pin assignments.

### Digital inputs (P1.2 - P1.7)

The connector block K1 allows connection of up to six input signals. All of these inputs connect directly to the microcontroller port P1. The state of these signals is displayed on LED array D1 via buffer IC4. If your application does not need this feature or you want to keep current consumption as low as possible then jumper J1 need not be fitted and these LEDs will remain off.

The two remaining inputs on P1.0 and P1.1 are used for switches S1 and S2.

### Digital outputs (P2.0 - P2.7)

Outputs P2.0 to P2.7 are buffered by IC3. Four of the outputs are used to drive relays RE2 to RE5 and these provide four switched outputs at connector K2. Two TTL level outputs OUT6 and OUT7 are also available at this connector. The state of these outputs is displayed by LED array D2 and again if this feature is not required jumper J2 need not be fitted.

### The Serial Interfaces

There are two serial interfaces supplied on the interface. K3 connects to the mobile phone while K4 connects to the serial port of an external computer.

IC7 (MAX207) converts the voltage level of the signals on both interfaces (V24) to TTL levels used on the interface card. A voltage of approximately 10 V is also produced by the outputs of T1OUT, T2OUT and T3OUT for the data cable. Removing jumper J3 will disconnect this voltage from the interface (see **Table 2**). Current to charge the battery in the mobile is supplied from pin 9 of connector K3 when jumper J5 is fitted. Sub-D connector K4 is used to connect to an external computer or process controller where SMS messages can be sent and received.

### SMS Chip peripheral circuits

The SMS chip, like all other 8051 processor derivatives requires a little bit of external peripheral circuitry. Firstly the address and data bus need to be demultiplexed at port P0 and this is performed by an octal D type flip flop (IC2) using the ALE signal. These address lines are now decoded by GAL IC5 to generate chip select signals for the rest of the components on the interface card. The address lines together with $\overline{RD}$/$\overline{WR}$, chip select ($\overline{CS}$) along with the supply voltage are available on pin-strip K5.

The circuit also includes a real-time-clock and a connector for an LCD both of which are controlled by the SMS chip.

### The RTC (Real Time Clock)

An accurate time reference is essential for some applications so a Real-Time-Clock (IC6) is included in the circuit. This chip maintains the correct time of day for the whole TFH-SMS-ExBo-System. A keep-alive battery (BT1) is charged via D7 and ensures that the RTC chip does not lose time if the main power from connector K8 fails.

### The alphanumeric LCD

An LCD can be attached to connector K6. The picture at the beginning of this article shows

## Chatting to the mobile

The SMS chip used in this interface card communicates with the mobile phone using Hayes compatible command sequences over its serial interface connection port. Back in the 70's modems were curious computer peripherals that just hung around whistling, waiting for the Internet to be invented. There were many modems on the market each model offering similar performance but with incompatible control commands. The pioneering US company Hayes came up with a set of commands that could be used to control the modem and it wasn't long before a modem was not worth considering unless it was 'Hayes compatible'. Even today the command sequences are still implemented in all modems and mobile phones.

The commands begin with the ASCII characters AT and the actual standardised commands start with the character string AT+C, all ending with the ASCII code for Carriage Return. These commands are also known as the 'AT' or 'AT+C' commands. These commands have more recently been adopted by the mobile phone industry and are defined in sections GSM07.07 and GSM07.05 of the GSM mobile phone specification for the control of phones over a serial interface. The interface can use V24 signal levels via a cable or IrDa infrared link. Altogether there are 55 AT commands listed which all of today's GSM phones must understand. These allow for example access to the telephone book in the mobile, managing SMS messages, adjusting ring tones and speaker volume etc.

Connecting a data link cable (Data cable) or using an infrared link between the mobile and the serial port of a computer means that it is now possible to control the mobile from a computer keyboard rather than the phone keypad. This is much easier on the fingers when sending text messages.

In addition to the standard commands each manufacturer has defined extra commands that will only be understood by their own mobiles. With the Siemens '35' series (S35i, C35i, M35i) there are 25 additional commands all prefixed with AT^S. This diversity creates problems for anyone considering building a universal SMS interface. It is necessary to study the phone specification closely to guarantee success. In this design all of these commands are pre-programmed into the SMS chip so that it can be directly connected to the Siemens '35' series of mobiles. Hardly any programming is necessary to develop a remote control application and even a second interface is provided at the remote site so that an external PC can be connected to provide more complex control possibilities. It is of course only necessary to specify this type of phone at the remote site, communication will occur over the air with any SMS-capable phone anywhere in the world!

a four line by 20 character display but most alphanumeric displays can be substituted provided that are compatible with the Hitachi HD44780 controller. Preset P1 allows the display contrast to be adjusted.

### The GAL chip

Chip select signals on the circuit are generated by IC5, a 16V8 Gate Array Logic (GAL) chip. The GAL chip simply reads the addresses at its input and generates chip select signals for the peripheral chips. The six chip selects $\overline{\text{CS0}}$ to $\overline{\text{CS5}}$ are also available on the pin strip K5.

### The power supply

IC8 is a fixed voltage regulator that supplies +5 V for the complete interface board and charging current for the mobile. The mains adapter unit should supply a voltage in the range of 9 to 12 V with a current of 800 mA, (including the mobiles charging current) connected to K7 or K8. D5 protects the circuit from accidental reversal of the power input leads and LED D3 is the power-on indicator. S4 is the on/off switch.

### Jumpers

The finished PCB has several jumper options and their purpose is outlined in **Table 2**.

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*In the second part of this article we will look closer at the connection between the mobile and this interface board, the basic configuration and command sequences of the SMS chip. We also look at the layout for the circuit.*

**Table 2. Jumper assignment**

| | | |
|---|---|---|
| J1 | Fit this jumper to activate LED-Array D1 (Displays the input status) | |
| J2 | Fit this jumper to activate LED-Array D2 (Displays the output status) | |
| J3 | Positive supply potential for the Data Link cable: | |
| | This jumper should be fitted when using an off-the-shelf Data Link cable, otherwise do not fit this jumper. | |
| J4 | Controls the charging current to the battery in the mobile (not used on Siemens S35): | |
| | Fitted (Low level): | Standard charge with 5 V at 150 mA |
| | Not fitted (High Z): | Fast charge with 5 V at 400 mA. Only fit this if using a custom made Data Link cable with charging function. (See part 2 of this article). |
| J5 | Positive charging potential for the battery in the mobile (not used on Siemens S35): | |
| | Fitted: | Allows mobile battery to be charged when using a custom-made Data Link cable (see part 2 of this article). |
| | Not fitted: | In all other cases. |